EXPERIMENTS

RELATING TO

ANIMAL ELECTRICITY;

FROM THE

TRANSACTIONS

OF THE

ROYAL SOCIETY OF EDINBURGH.

EXPERIMENTS *relating to* ANIMAL ELECTRICITY. *By ALEXANDER MONRO,* M. D. F. R. S. EDIN. *Fellow of the Royal College of Phyſicians, Profeſſor of Medicine, Anatomy and Surgery in the Univerſity of Edinburgh, Fellow of the Royal Academy of Surgery in Paris,* &c. &c.

[*Read Dec.* 3. 1792.]

ON the 3d of November laſt, Sir JAMES HALL and Dr RUTHERFORD aſked me to repeat with them ſome experiments on what has been called Animal Electricity, which were firſt performed by Dr GALVANI, Profeſſor of Anatomy at Bologna, and of which an account had been communicated by Mr SEGUIN of Paris to Dr BLACK, in a letter dated Paris, 3d Auguſt.

WE accordingly, with the help of my aſſiſtant Mr FYFE, repeated them in the following manner:

WE cut a living frog into two parts, a little above the lower end of the ſpinal marrow. We then put the middle part of a bit of tinfoil, about one-tenth of an inch in breadth, and two inches long, under the beginning of one of the ſciatic nerves, and then doubled the tinfoil over the nerve, that is, we included the nerve in the doubling of the tinfoil. We next placed one half crown ſilver piece between the table and loins of the frog, and another between the table and its leg. We then bended a piece of braſs-wire, about the ſize of a common

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ſtocking-wire, and after laying one end of it upon the half-crown piece which ſupported the leg, we with the other end of the wire preſſed the doubled tinfoil againſt the half-crown piece which ſupported the loins, and found, that inſtantly convulſions were produced in the muſcles of the thigh and leg.

WHEN the tinfoil was paſſed around both ſciatic nerves, both legs were convulſed, although the half-crown piece was placed under one of the legs only. Theſe experiments were tried more than an hour after the ſpinal marrow had been cut acroſs, with the ſame ſucceſs.

IN another frog, in which the ſpinal marrow was not divided, we found the ſame means produce the ſame effects upon the legs, but did not obſerve, that the muſcles above the tinfoil in the trunk or fore-legs were affected.

WHEN the touches were quickly repeated, the motions ſeemed to become, by degrees, leſs vigorous, but did not ceaſe after repeating them often, even where the ſpinal marrow had been divided tranſverſely.

ON the 10th of November, I proſecuted the ſubject farther by the following experiments:

EXPERIMENT I.

AFTER cutting off the hind legs of a living frog, I laid bare the upper part of its ſpinal marrow, and ſurrounded it with tinfoil; and in another frog, after laying bare the brain, I thruſt into it a bit of tinfoil. I then placed one half crown piece between the table and the body of the frog, oppoſite to the tinfoil, and another half-crown piece between the table and the lower part of the trunk of the animal, and, on applying the wire, as before, I found convulſions produced in the fore-legs and body. Gold had nearly the ſame effect as ſilver; but the convulſions

convulſions were much leſs obſervable, when lead, iron or copper were ſubſtituted inſtead of theſe.

EXPERIMENT II.

I NEXT tried all the above mentioned experiments with one half-crown piece only, placed oppoſite to the tinfoil; and on preſſing the tinfoil againſt the ſilver-piece, by means of a braſs-wire which I held in my hand, I found, that the muſcles were convulſed exactly in the ſame manner as where two pieces of the ſilver were employed in the manner before mentioned.

EXPERIMENT III.

I FOUND likewiſe, that the experiment ſucceeded equally well, although the ſilver-piece did not touch the body of the animal, but was merely brought into contact with the tinfoil put around the nerve, by preſſure with a braſs-wire held in the hand.

EXPERIMENT IV.

AFTER incloſing the upper part of the ſciatic nerve in tinfoil, I tied a linen-thread around it, where it is about to paſs from the trunk into the thigh, ſo tight as to deprive the muſcles of their power of acting by the ordinary exertions of the animal, and the ſkin and toes of their feeling, yet when, with a braſs-wire held in my hand, I preſſed the tinfoil againſt the ſilver-piece, the muſcles of the limb were violently convulſed.

EXPERIMENT V.

I DIVIDED tranſverſely all the parts of a frog at the pelvis, then tied together the divided parts of one of the ſciatic nerves with a linen thread. I afterwards paſſed the tinfoil around the nerve, at a conſiderable diſtance above the ligature, and found, that when, with a braſs wire, I preſſed the tinfoil againſt a half-crown piece, laid on the table at a little diſtance from the frog, the muſcles of the leg were inſtantly convulſed.

EXPERIMENT VI.

WHEN, after dividing both ſciatic nerves tranſverſely, I tied the upper part of the right ſciatic nerve, incloſed in the tinfoil, to the lower part of the left ſciatic nerve, and then, with a braſs wire, preſſed the tinfoil againſt a piece of ſilver, the muſcles of the left leg were convulſed.

EXPERIMENT VII.

THE event was the ſame when the divided parts of the nerves were croſſed over each other, without being tied together.

EXPERIMENT VIII.

THE event was the ſame, when the animal, with the metals, were placed on the top of a large glaſs-jar inverted, or on a plate of window-glaſs, ſupported on two pieces of ſealing-wax.

EXPERIMENT IX.

I PASSED the tinfoil around portions of the ſkin, the muſcles, the inteſtines, and around the femoral blood-veſſels of frogs, without obſerving convulſions produced, when the tinfoil was applied to the ſilver by means of the braſs-wire.

EXPERIMENT X.

I LAID bare the ſciatic nerve in the back part of the thigh of a young rabbit, and incloſed it in tinfoil, and then applied the tinfoil, by means of a braſs-wire, repeatedly to a half-crown piece, laid on the table, and obſerved convulſions of the leg produced on each application. I after that cut tranſverſely the lower part of the ſpinal marrow, and then, with a braſs-wire held in my hand, I preſſed the tinfoil again to the ſilver, and kept it applied for a few ſeconds, which occaſioned convulſions ſo quickly repeated, that the leg became rigid. Immediately thereafter, the muſcles were relaxed, and their contractile power ſeemed to be exhauſted, as repeated applications of the tinfoil to the ſilver produced no farther motion of the limb.

REMARKS AND QUERIES.

FROM the accounts we have received of the experiments of Dr GALVANI and Dr VALLI, it appears, that both theſe celebrated authors have ſuppoſed, " That the circulation of the " nervous fluid from the nerves to the muſcles, is nearly ſimilar " to the circulation of artificial electricity in the Leyden phial ; " and

" and as the circulation of the Leyden phial ſuppoſes two con-
" trary electricities, the one more condenſed or poſitive, and
" the other leſs ſo or negative, ſo Profeſſor GALVANI concludes,
" that a ſimilar diſtinction takes place in the bodies of animals,
" and that one of theſe electricities, to wit, the condenſed or
" poſitive, is ſeated in the nerves, and the other in the muſcles *."

HENCE both of them have conceived it neceſſary, to eſtabliſh a communication between the nerve and the muſcle, by means of metalline coating of the nerve and pieces of metal and metalline conductors; or by coating the nerve with lead or tin, then laying one piece of ſilver in contact with the tin, and another in contact with the muſcle; and, in the laſt place, eſtabliſhing a communication between the two pieces of metal, or between the nerve and the muſcle, by means of a braſs-wire, which they term a conductor †.

BUT, inſtead of this complex apparatus, I have found, from the above experiments, that the muſcle is thrown into action, although no metal is directly in contact with it, or when the communication between the metals and the muſcle is made by the nerve alone.

IT appears therefore, that Profeſſor GALVANI and Dr VALLI have allowed preconceived theory to conduct their experiments, inſtead of allowing their experiments to conduct their theory; in conſequence of which, ſeveral of their experiments have been performed with leſs accuracy than might have been expected. Thus, they tell us, that if the conductor is firſt applied to the muſcle, the convulſions are ſtronger than when it is firſt applied to the nerve; that the ſhocks are ſtronger when the feet communicated with the earth, *&c.* whereas the application of the conductor to the muſcles, or of the feet to the earth, are quite out of the queſtion.

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* See Medical Facts and Obſervations, Lond. 1792. p. 187, 188.

† Ditto, p. 187. 191. 211.

2. We have found, that when a piece of ſilver is brought in contact with the tinfoil coating of a nerve, the muſcles in which that nerve terminates, are thrown into action, although the nerve has been ſurrounded with a tight ligature between the coating and the muſcle, or even although it has been divided by a tranſverſe inciſion, provided the divided parts are again brought into contact, or tied together by a thread.

3. When we tie the coated nerve, after it is cut tranſverſely, to another nerve which has been cut tranſverſely, we have found, that the muſcles ſupplied by the latter are thrown into action.

4. After the ſpinal marrow and whole body of the frog were divided tranſverſely about the middle of the back, and the tin coating and ſilver were applied to the ſciatic nerve, I did not obſerve, that the muſcles at the loins and pelvis were thrown into action, or the effect produced by the metals did not influence muſcles ſupplied by branches of nerves ſent off from the ſpinal marrow or ſciatic nerves above the coating.

It appears, that the nerve of a living animal, whether entire, or cut and rejoined, conducts that matter by which the muſcle is influenced more readily than the ſkin, the fleſh or the blood-veſſels do.

5. Although, on repeating Dr Galvani's experiments, it ſhould be proved, that electrical matter, drawn from a cloud or excited by the common machinery, and conducted to a nerve, and that matter, which is put in motion by the application of certain metals to each other and to a nerve, produce ſimilar motions in the muſcles in which the nerve terminates, we are not at liberty to take for granted, as Galvani and Valli ſeem to have done, that the electrical matter and this matter are the ſame, as the nerves may be affected by ſtimuli of different kinds.

6. As an animal does not feel nor act by the medium of a nerve which has been divided tranſverſely, although its divided parts are placed contiguous, or tied together; as the muſcles ſupplied by nerves above the place coated are not thrown into action; the above experiments, or thoſe of GALVANI and VALLI, inſtead of proving, as they have ſuppoſed, that the matter which is excited is electrical, and the fluid of the nerves the ſame with it, appear to ſhow, that the electrical fluid, or matter put in motion by the different metals, is quite different in its nature from the nervous fluid, as the courſe of the nervous fluid, but not that of the electrical, can be intercepted by ligature or inciſion of the nerve.

7. As the action of the muſcles, in the above experiments, is not produced, nor even increaſed, by connecting the coating of the nerve with the muſcle by means of a wire, there is no foundation for the opinion of GALVANI and VALLI, that the nerve is electrified plus, and the muſcle minus, or that the electricity of the one is poſitive, and that of the other negative.

8. WE ſeem therefore to be led to the concluſion, that the matter or fluid which is excited or put in motion by the application of the different metals to each other, and to the nerve, ſerves merely as a powerful ſtimulus to that energy or fluid which is lodged in the nerves.

To ſupport this way of reaſoning, we may obſerve, that in a warm-blooded animal, the rabbit, although convulſions were repeated for a conſiderable length of time when the nerve was entire, yet, after dividing the nerve and intercepting the further ſupply of nervous energy from the brain, the action of the muſcles ceaſed in a few ſeconds, by keeping the two metals contiguous, which is readily explained on the ſuppoſition, that the nervous energy or fluid, lodged in the nerve beyond the place of the inciſion, was exhauſted; and Dr VALLI himſelf, by obſerving, that, after the electricity, as he calls it, of a limb is exhauſted, if the coating of a nerve be moved higher up, the action of the muſcles may be renewed *, furniſhes a fact which, I apprehend, may be explained on the ſame principle.

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* Medical Facts and Obſervations, Art. xx. p. 218.

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